BRUSH INSTRUMENTS

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OPERATING INSTRUCTIONS FOR

HIGH GAIN D. C. AMPLIFIER

Model BL-550

BRUSH ELECTRONICS COMPANY
3405 PERKINS AVENUE CLEVELAND 14, OHIO

(2)

BRUSH ELECTRONICS COMPANY

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PROPERTY OF ENGINEERING
TEST CONSTRUCTION
ITEM 4 COPY 2
48 HOUR LOAN

OPERATING INSTRUCTIONS FOR

HIGH GAIN D. C. AMPLIFIER

Model BL-550

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*T.M.

BRUSH ELECTRONICS COMPANY
3405 PERKINS AVENUE
CLEVELAND 14, OHIO

WARRANTY

We warrant each instrument manufactured by Brush Electronics Company to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and replacing any defective parts thereof (except pens, tubes, fuses and batteries).

This warranty is effective for one year after delivery to the original purchaser, when the instrument is returned transportation charges prepaid by the original purchaser, and which upon our examination proves to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at our current rate. In this case, an estimate will be submitted before the work is started. This warranty is in lieu of all other warranties, expressed or implied.

Warranty card enclosed with shipment must be returned to establish warranty.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be examined as soon as it is received. If it is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained from the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, type number and serial number when referring to this instrument for any reason.

IF ANY FAULT DEVELOPS, THE FOLLOWING STEPS SHOULD BE TAKEN:

1. Notify our Customer Service Department, 3405 Perkins Avenue, Cleveland 14, Ohio, giving full details of the difficulty, and include the model number, type number and serial number. Upon receipt of this information, we will give you service instructions or issue a material return authorization card.
2. You may request any necessary instrument packaging by telling us what cartons you need. These will be sent to you no charge.
3. Upon receipt of shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

SHIPPING

All shipment of instruments should be made via Railway Express.

PLEASE DO NOT HESITATE TO CALL ON US.

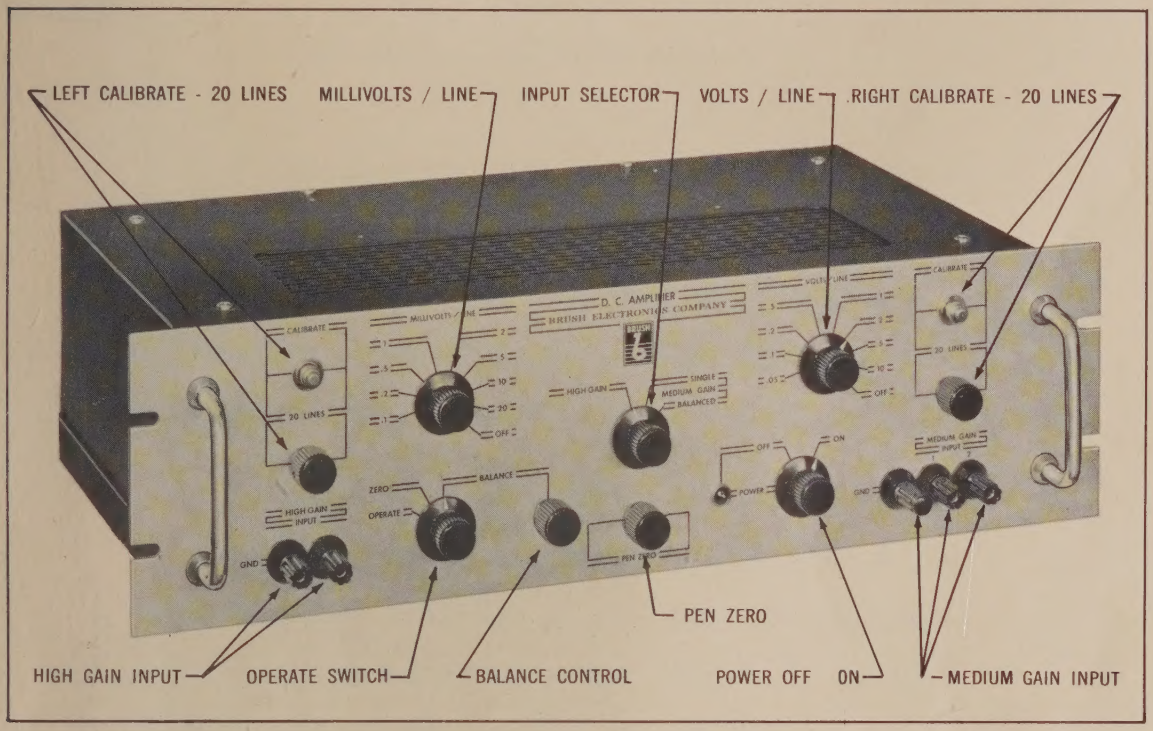

Fig. 1. Brush High Gain DC Amplifier Model BL-550

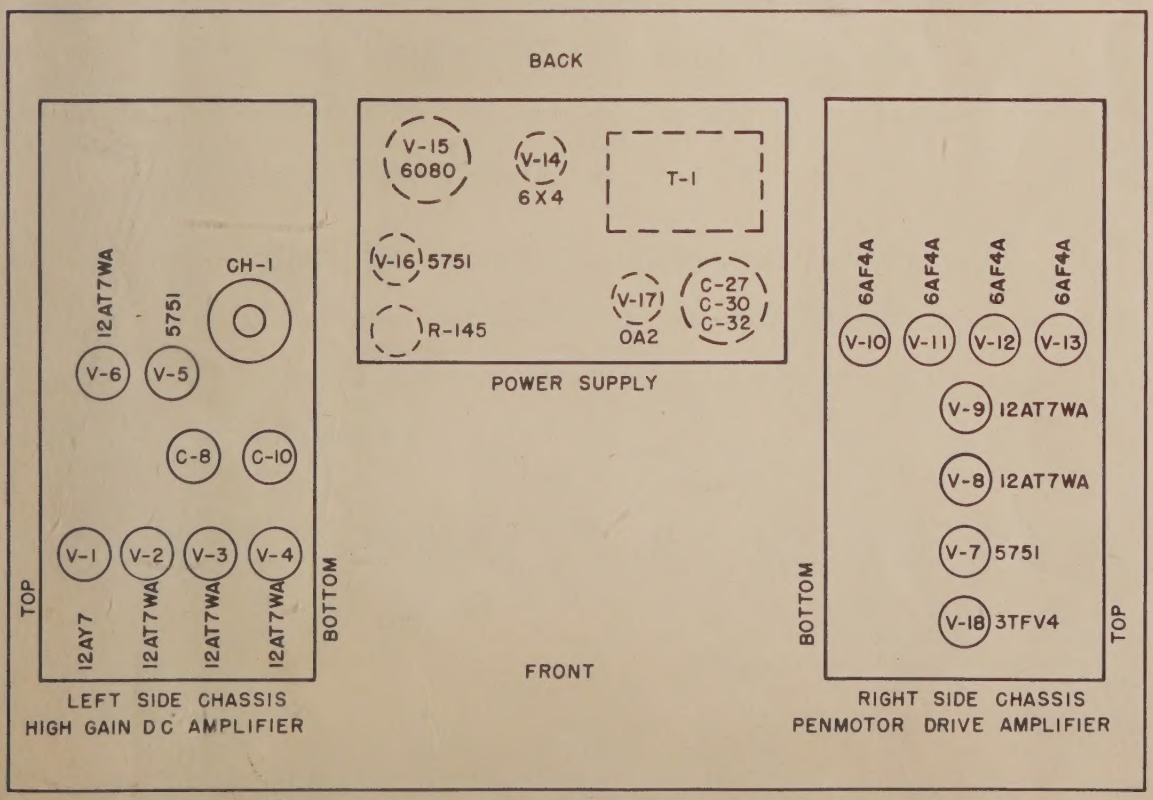

Fig. 2. Tube Layout

HIGH GAIN D.C. AMPLIFIER Model BL-550

The Brush High Gain D.C. Amplifier Model BL-550, is a low drift, very high gain, general purpose DC amplifier designed for laboratory or field instrumentation, particularly when used in connection with a matching Brush Oscillograph.

A high degree of stability and freedom from environmental effects is inherent in this unit. A feedback circuit consisting of a chopper and a high gain AC amplifier contribute to this stability. The unit will accept a wide range of signals (from 100 microvolts to 500 volts). The input impedance is 1 megohm. A high gain, single ended input and a medium gain, balanced or single ended input, as well as two attenuators, add flexibility.

This High Gain D.C. Amplifier will fit a standard 19" rack or may be mounted in a specially designed Portable Case Model BL-380, for semi-permanent, table-top applications.

* * *

BL-550
298

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269

BRUSH ELECTRONICS COMPANY
3405 PERKINS AVE. • CLEVELAND 14, OHIO • U.S.A.

SPECIFICATIONS

Sensitivity	100 microvolts/mm to 10 volts/mm.
Attenuator ratios	High Gain Section - .1, .2, .5, 1, 2, 5, 10, and 20 mv/mm lines of chart paper. Medium Gain Section - .05, .1, .2, .5, 1, 2, 5, amd 10 v/mm lines of chart paper.
Frequency response	Flat within ± 1 db from 0 (DC) to 5 kilocycles. Flat within ± 1 db from 0 (DC) to 100 cycles with Brush Oscillographs.
Calibration	Internal Mercury cell. High Gain section, 2 millivolts ± 1%. Medium Gain section, 1 volt ± 1%.
Impedance	High Gain section, 1 megohm. Medium Gain section - single ended input, 1 megohm - balanced input, 900 kilohms.
Input signal	High Gain section - single ended. Medium Gain section - balanced or single ended.
Zero off-set	Equivalent to 200 mm chart lines.
Input Voltage range	High Gain section, 100 microvolts to 0.4 volt. Medium Gain section, 0.4 volts to 500 volts.
Power required	105 to 125 volts, 60 cps - 85W (nominal)
Fuse	2 Amp. 250 volts, 3 AG.
Tubes	DC amplifier: 12AY7 and 3 each of 12AT7WA's. Correction amplifier: 12AT7WA and 5751. Power supply: 6X4, 6080, 5751 and 0A2. Drive amplifier: 5751, 2 each of 12AT7WA's and 4 each of 6AF4A's.
Dimensions	Standard panel: 19" wide x 5¼" high and ¼" thick. Behind front panel: 10-3/4" deep (with connectors 12-1/2" deep).
Net weight	22 pounds
Shipping weight	28 pounds

POWER OFF-ON:	Main power supply OFF-ON switch.
MEDIUM GAIN INPUT:	GR terminals for medium gain, single ended or balanced input signal. Terminal to the left is ground and is so marked on panel.

The controls and connectors on the rear panel are as follows:

NARROW COMP: (narrow compensator)	Frequency compensator for matching penmotor.
BROAD COMP: (broad compensator)	Same as above.
TUBE ADJ: (tube adjustment)	To be used only in case of tube replacements. (See Routine Adjustment & Maintenance)
POWER INPUT:	Connects 115V a.c. to amplifier. (2 pin recessed male connector)
OUTPUT:	Connects amplifier output to oscillograph or other equipment. (6 pin female AN connector)
MEDIUM GAIN INPUT:	This connector is parallel with the MEDIUM GAIN INPUT on the front panel. Pin "A" parallels "GND" (ground); pin "B" parallels terminal "1" and pin "C" parallels terminal "2".
GRID CURRENT:	Neutralizes the effect of the input grid current in the high gain amplifier section.
SIGNAL BAL: (signal balance)	Adjusts the correction feedback ratio of the high gain section of the amplifier and thereby the stability.
PLATE ADJ: (plate adjustment)	Adjusts the output DC level of the high gain section of the amplifier.

* * *

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OPERATING PROCEDURE

The following procedures will consider three different and distinct operating conditions and in this order, namely: medium gain with balanced input, medium gain with single ended input and high gain with single ended input. Selection as to the use of the high or medium gain section is based upon the input voltage. The high gain section should be used for input voltages below 0.4 volt; while the medium gain should be used for input voltages in the range between 0.4 volt and 500 volts. It is recommended that the medium gain be tried first if the input voltage is not known. All three of the above conditions have a common set-up. To make this set-up proceed as follows:

1. Turn POWER OFF-ON switch to "OFF".
2. Turn both LEFT CALIBRATE-20 LINES and RIGHT CALIBRATE-20 LINES controls counterclockwise as far as possible.
3. Turn both the MILLIVOLTS/LINE and the VOLTS/LINE selectors to "OFF".
4. Turn OPERATE SWITCH TO "OPERATE".
5. Turn PEN ZERO counterclockwise as far as possible. Then clockwise 5 full turns. This will be approximately the center of this 10 turn control.
6. Connect the oscillograph to an appropriate power source.
7. Turn the oscillograph to "ON".
8. Center the pen on the chart paper by means of the pen centering lever of the oscillograph.
9. Turn the oscillograph to "OFF".
10. Connect the amplifier to the oscillograph.

MEDIUM GAIN - BALANCED INPUT

For a medium gain, balanced input operation, complete the preliminary set-up as explained on Page 5 and proceed as follows:

1. Turn the INPUT SELECTOR to the MEDIUM GAIN-BALANCED position.
2. Connect the amplifier to an appropriate power source.
3. Turn the POWER OFF-ON switch to "ON". Allow the amplifier 10 to 15 minutes to warm up.
4. Connect the signal input to the amplifier by means of either the front panel (GR) terminals marked "MEDIUM GAIN -INPUT 1 and 2" or to the rear panel (AN) connector marked "MEDIUM GAIN INPUT". Pin "A" of the rear panel (AN) connector is in parallel with the (GR) terminal on the front panel marked "MEDIUM GAIN INPUT -GND" (ground) terminal; while pin "B" is parallel to the "MEDIUM GAIN - INPUT 1" terminal and pin "C" is parallel to the "MEDIUM GAIN - INPUT 2" terminal.
5. If necessary zero the pen trace to the center of the chart paper by means of the TUBE ADJ (tube adjustment) on the rear panel.
6. Depress RIGHT CALIBRATE switch and adjust RIGHT CALIBRATE -20 LINES control for 20 mm lines of pen deflection.
7. Release RIGHT CALIBRATE switch.
8. Adjust VOLTS/LINE selector to desired sensitivity. Each successive step in a counterclockwise direction increases the sensitivity. The signal voltage is equal to the number of lines of deflection of the pen trace from the pen zero, multiplied by the VOLTS/LINE setting.

MEDIUM GAIN - SINGLE ENDED INPUT

For medium gain, single ended input operation, complete the preliminary set-up as explained in the first 10 steps of the "OPERATING PROCEDURE" and proceed as follows:

1. Turn the INPUT SELECTOR to the MEDIUM GAIN - SINGLE position.
2. Connect the amplifier to an appropriate power source.
3. Turn the POWER OFF-ON switch to "ON". Allow the amplifier 10 to 15 minutes to warm up.
4. Connect the signal input to the amplifier by means of either the front panel (GR) terminals or the rear panel (AN) connector. When connecting a single ended input signal at the front panel, the "hot" side (in reference to ground) must be connected to the MEDIUM GAIN - INPUT 2 terminal and the side of the circuit to be grounded to the MEDIUM GAIN - INPUT 1 terminal. If the rear panel input connector is used, the "hot" side of the signal (in reference to ground) must be connected to pin "C" and the ground connected to pin "B" of the AN connector.
5. Again zero the pen in the center of the chart paper by means of the PEN ZERO control.
6. Depress RIGHT CALIBRATE switch and adjust RIGHT CALIBRATE - 20 LINES control for 20 mm lines of pen deflection.
7. Release RIGHT CALIBRATE switch.
8. Adjust the VOLTS/LINE selector to desired sensitivity. Each successive step in a counterclockwise direction increases the sensitivity. The signal voltage is equal to the number of lines of deflection of the pen trace from the pen zero, multiplied by the VOLTS/LINE setting.

HIGH GAIN - SINGLE ENDED INPUT

For high gain, single ended input operation, complete the preliminary set-up as explained in the first 10 steps of the "OPERATING PROCEDURE" and proceed as follows:

1. Turn the INPUT SELECTOR to the HIGH GAIN position.
2. Connect the amplifier to an appropriate power source.
3. Turn the POWER OFF-ON switch to "ON". Allow the amplifier 10 to 15 minutes to warm up.
4. Place an open shielded GR type connector over the HIGH GAIN INPUT terminals.
5. Turn the MILLIVOLTS/LINE switch as far as possible in a counterclockwise direction to point marked ".1" on the panel.

   NOTE: FOR MAXIMUM ACCURACY, CALIBRATION MUST BE MADE AT THE .1 POSITION. THE FIRST THREE ATTENUATOR STEPS ARE CONNECTED TO THE OUTPUT OF THE HIGH GAIN SECTION. THUS OUTPUT FROM THE CALIBRATION SIGNAL IS ALSO REDUCED BY THE ATTENUATOR; i.e. THE SIGNAL CALIBRATED FOR 20 LINES WITH THE MILLIVOLTS/LINE SWITCH IN THE .1 POSITION, WILL REDUCE TO 10 LINES IN THE .2 POSITION; TO 4 LINES IN THE .5 POSITION AND TO 2 LINES WHEN IN POSITIONS 1 TO 20.
6. Turn OPERATE SWITCH to position marked "ZERO".
7. Adjust pen trace to the center line of the chart paper by means of the PEN ZERO control.
8. Turn OPERATE SWITCH to BALANCE position.
9. By means of the BALANCE CONTROL again adjust the pen trace to approximately the center line of the chart paper. With the OPERATE SWITCH in the BALANCE position the correction circuit of the high gain section of

HIGH GAIN - SINGLE ENDED INPUT (cont'd)

the amplifier is disconnected. Therefore, the amplifier's inherent drift will be indicated on the chart paper. The purpose of the BALANCE CONTROL is to adjust the amplifier to an approximately balanced condition, so that the amplifier need correct for only a small error.

10. Turn OPERATE SWITCH to the ZERO position and check pen trace as to center line of the chart paper. If pen does not center on the chart paper, readjust with the PEN ZERO control.

11. Turn OPERATE SWITCH to the OPERATE position. NOTE: Because of the high sensitivity of the amplifier in this operating condition, it must be protected from all stray noise pickup.

12. Depress LEFT CALIBRATE switch and adjust LEFT CALIBRATE-20 Lines control for an overall total of 20 lines of pen deflection.

13. Release LEFT CALIBRATE switch.

14. If pen trace does not return to the zero line, but is off less than 1 mm line of chart paper, readjust to the zero line by means of the PEN ZERO control. If the pen trace is more than 1 mm line off the center line of the chart paper, center the pen trace on the chart paper by means of the GRID CURRENT adjustment on the rear panel of the amplifier.

15. Turn MILLIVOLTS/LINE switch to "OFF".
NOTE: THE ABOVE STEP IS VERY IMPORTANT BEFORE CONTINUING WITH THE NEXT STEP.

16. Remove the open shielded CR type connector previously placed across the HIGH GAIN INPUT terminals. (Step 4, above)

HIGH GAIN - SINGLE ENDED INPUT (cont'd)

17. Connect the desired input signal to the HIGH GAIN INPUT terminals by means of a shielded GR type of connector.

18. Advance the MILLIVOLTS/LINE switch in a counterclockwise direction to the desired operating position.

When operating in the High Gain position, the pen trace may be moved from the center line of the chart paper to any arbitrary position on the chart paper by means of the PEN ZERO control. This arbitrary position becomes the zero reference line.

OFF CENTER ZERO OPERATION: (When using medium gain section with single ended input only)

It is sometimes desirable to balance out the static component and magnify the dynamic component of a complex signal. This is accomplished by theoretically moving the signal zero or reference line off the chart paper and centering the center of the dynamic component on the center line of the chart paper. After placing the INPUT SELECTOR in the MEDIUM GAIN - SINGLE position, display the signal on an appropriate VOLTS/LINE setting, using either the front panel (GR) MEDIUM GAIN INPUT terminals or the rear panel (AN) connector. Zero the pen on the center line of the chart paper by means of the PEN ZERO control and turn the VOLTS/LINE switch to the next lower setting. Follow this by turning the PEN ZERO control until the pen records equal amplitude of the dynamic signal component on either side of the center line of the chart paper. The above procedure may be repeated until the dynamic signal amplitude is as great as possible without exceeding 40 lines (peak to peak) of the chart paper or until the d.c. (static component) center shift is 200 mm off chart center. This is the maximum available shift off chart center, obtainable by adjustment of the PEN ZERO control, (to either extreme of its

rotation) at any VOLTS/LINE switch position. The peak to peak voltage of the signal under observation is equal to the number of chart mm lines (peak to peak) multiplied by the setting of the VOLTS/LINE switch.

* * * * * *

ROUTINE ADJUSTMENT and MAINTENANCE

This amplifier has been accurately balanced and adjusted before shipment from the factory and should give long, trouble-free service. For any servicing other than tube replacement, the instrument should be sent back to the factory where facilities are available to restore it to its original condition.

TUBE REPLACEMENT

To replace any faulty tube, begin by disconnecting all cables and exposing the chassis. If the amplifier is portable case mounted, remove the top and bottom screws as well as the four screws on the front panel and withdraw the amplifier. If the amplifier is rack mounted, remove it from the rack and take off the top portion of the wrap-around cover. In either case all tubes will be exposed.

Following any tube replacement, restore the top portion of the wrap-around cover (if any) and replace the instrument in either the rack or portable case.

Right Side Chassis

If any of the 6AF4's or the 12AT7WA's are replaced, proceed as follows:

1. Remove the 5751 (V-7) tube from the right side chassis (See Fig. 2). IMPORTANT: This tube remains out during adjustment, regardless of which tube of the pen drive amplifier was replaced.
2. Warm up amplifier (10 to 15 minutes).
3. Connect the oscillograph to an appropriate power source.
4. Turn "ON" the oscillograph and center the pen by means of the pen centering lever.
5. Connect amplifier to oscillograph and with the oscillograph connected and operating, adjust pen to zero (center line) of the chart paper, by means of the adjustment control on the back panel marked "TUBE ADJ" (tube adjustment). This operation balances the medium gain d.c. section of the Right Side Chassis of the amplifier.
6. Replace the 5751 tube previously removed. Zero pen by means of PEN ZERO control.

Power Supply Chassis

Following the replacement of any tube in this section (Fig. 2) the B+ voltage must be checked and adjusted. The voltage between the case of the condenser C-27 and pin 5 of the OA2 tube (V-17), must be adjusted to 213 volts (± 5 volts) by means of the control (R-142).

Left Side Chassis

If any tubes are replaced in the left side chassis, it will be necessary to re-balance this section. To re-balance this section, expose the chassis as explained under "Tube Replacement" and proceed as follows:

1. Replace the faulty tube.
2. Connect the amplifier to an appropriate power source.
3. Warm up amplifier (10 to 15 minutes).
4. Turn INPUT SELECTOR to HIGH GAIN position.
5. Turn OPERATE SWITCH to ZERO position.
6. Turn oscillograph to "ON" and adjust pen to center line of chart paper by means of the PEN ZERO control.
7. Turn the oscillograph to "OFF".
8. Place an open, shielded GR type connector over the HIGH GAIN INPUT terminals.
9. Turn the LEFT CALIBRATE - 20 LINES control fully clockwise.
10. Turn the MILLIVOLTS/LINE switch to the .1 position.
11. Turn the OPERATE SWITCH to BALANCE position.
12. By means of a DC voltmeter, measure the DC voltage from chassis (ground) to pin 1 and from chassis to pin 6 of the 12AT7WA (V-4) tube. See Tube Layout - Fig. 2.
13. By means of the BALANCE CONTROL on the front panel of the amplifier, adjust for equal DC voltage readings in step 12, above.
14. By means of the PLATE ADJ (plate adjustment) on the rear of the amplifier, adjust the DC voltage reading between the chassis and pin 1 in step 12, above, to zero (0) $\pm$ 1 volt.
15. Repeat steps 12, 13 and 14, above, until the DC voltmeter readings from chassis to pin 1 and from chassis to pin 6 of the 12AT7WA (V-4) tube are zero (0), $\pm$ 1 volt. This may have to be repeated.

16. Restore the wrap-around cover or replace the instrument in its portable case. (This is to prevent pickup of stray noise.)

17. Turn oscillograph to "ON" and adjust pen to approximately center line of chart paper by means of the BALANCE CONTROL on the front of the amplifier.

18. Depress the LEFT CALIBRATE SWITCH several times. The deflection of the pen trace must average in excess of 20 lines of chart paper. NOTE THIS AVERAGE AS IT WILL BE USED LATER FOR REFERENCE. (If the deflection of the pen averages less than 20 lines, check the voltage of the internal mercury cell. It must be 1.35 v ± 1%.)

19. Turn OPERATE SWITCH to OPERATE position.

20. Displace pen trace to left side of chart paper by means of the PEN ZERO control.

21. Depress LEFT CALIBRATE SWITCH and adjust pen trace to the same number of lines of pen deflection as observed in step 19 above, by means of the SIGNAL BAL (signal balance) control on the rear of the amplifier.

22. Restore the pen trace to the center line of the chart paper by means of the PEN ZERO control.

23. Turn OPERATE SWITCH to the BALANCE position.

24. Center the pen trace approximately on the center line of the chart paper by means of the BALANCE CONTROL.

25. Turn OPERATE SWITCH to the ZERO position.

26. If necessary, restore the pen trace to the center line of the chart paper by means of the PEN ZERO control.

27. Turn OPERATE SWITCH to the OPERATE position.

28. Depress LEFT CALIBRATE switch and adjust to 20 lines of pen deflection by means of the 20 LINES control.

29. Center the pen trace on the chart paper by means of the GRID CURRENT adjustment on the rear of the amplifier.

30. Recalibrate for 20 lines of pen deflection by means of the LEFT CALIBRATE - 20 LINES control. It may be necessary to repeat the above steps 23 through 30.

FREQUENCY COMPENSATION

To obtain optimum frequency response of an amplifier-oscillograph combination, the frequency response of the amplifier must be adjusted to match the penmotor of the oscillograph. (When an amplifier and an oscillograph are purchased together, this adjustment is made at the factory.)

To match an amplifier to an oscillograph, proceed as follows:

1. Turn INPUT SELECTOR to the MEDIUM GAIN - SINGLE position.
2. Warm up amplifier (10 to 15 minutes).
3. Adjust pen pressure of oscillograph with a gram gage (Brush Model BL-801) to 1 gram. (See Operating Instructions for Oscillograph.)
4. Connect an oscillator covering the range from 10 to 100 cps to either the front panel (GR) MEDIUM GAIN - INPUT terminals or the rear panel (AN) connector. Pin "D" is the ground and pin "C" is the "hot" terminal on the rear connector.
5. Turn BROAD COMP (broad compensator) switch fully counterclockwise.
6. At 10 cps adjust input for 10 lines total pen deflection (peak to peak)
7. At 100 cps (with the oscillator input voltage the same as in step 6 above) adjust the NARROW COMP (narrow compensator) on the back panel of amplifier for maximum pen amplitude. If the maximum pen amplitude

is 10 or more chart paper lines, adjust the NARROW COMP (narrow compensator) adjustment on the rear panel of the amplifier until the oscillograph records exactly 10 lines. If the maximum obtainable pen amplitude is less than 10 lines of chart paper, advance the BROAD COMP (broad compensator) switch on the rear panel of the amplifier in single steps in a clockwise direction until by adjustment of the NARROW COMP (narrow compensator) control the oscillograph records 10 lines of pen deflection.

8. Check the frequency response (10 to 100 cps).
9. If frequency response is not flat (± 1 line) between 10 and 100 cps, reset the NARROW COMP (narrow compensator) adjustment on the opposite side of the response "hump" at 100 cps, as previously adjusted in step 7 above.
10. Recheck the frequency response (10 to 100 cps).

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Instruments For MODERN MEASUREMENTS

RECORDING SYSTEMS

BRUSH ELECTRONICS COMPANY
DIVISION OF CLEVITE CORPORATION
3405 PERKINS AVENUE • CLEVELAND 14, OHIO

BRUSH ELECTRONICS

BRUSH AMPLIFIERS Put MEASUREM

WHAT DO YOU WANT TO MEASURE?

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FORCE	DISPLACEMENT
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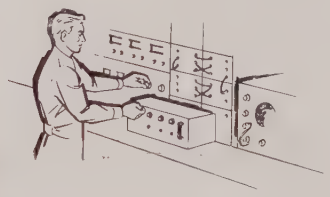
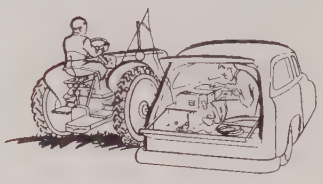
VIBRATION
PHYSIOLOGICAL STUDIES OF BRAIN, HEART AND NERVE POTENTIALS
WELDING ANALYSIS
NOISE STUDIES

Typical industrial and research applications of BRUSH INSTRUMENTS.



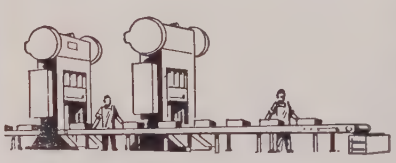
LABORATORY

Brush Recording Systems are widely used in the research laboratory; they are invaluable tools to the design engineer in his development of new and better products.



FIELD TESTING

Brush Recording Systems may be used to measure the performance of your products; and, to put the answer in writing immediately for "on the spot" analysis.



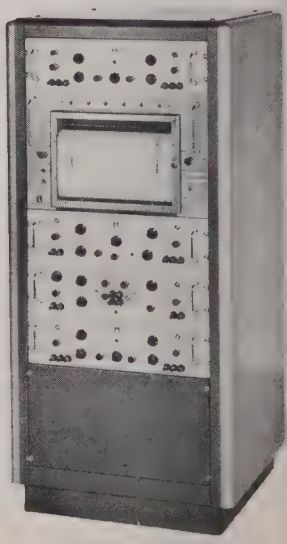
PRODUCTION

Brush recording equipment is equally at home on the production line, for spot checks and for continuous control on the quality and performance of manufactured items — and on the equipment used to produce them.

Typical BRUSH RECORDING SYSTEM

BL-266 Six Channel Construction Ink and Electric Writing Oscillograph with following AMPLIFIERS:

- BL-550 High Gain D.C. Amplifier (chopper stabilized)
- BL-530 Dual Channel D.C. Amplifier
- BL-520 Universal Amplifier (carrier type)



BRUSH RECORDING INSTRUMENTS

n measure the light from a star—or the strain in a mammoth shovel. With a Brush oscillograph these measurements are writing instantly. Brush Direct Writing Oscillographs pro- sible and indisputable proof of the measurement in a perman- m.

g the many different types of measurements that may be ed are for example, electrical transients in power lines and tric motors and generators, stresses and vibrations in industrial nent; the telemetered flight characteristics of guided missiles rcraft; the performance of control mechanisms; and, the out- rom analog and digital computers.

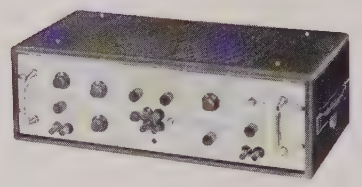
esign of these sensitive instruments provides a high degree uracy. Brush engineering and quality control in manufacture nade them physically rugged. You can depend on their opera- the laboratory, on the production line, or under field condi-

pioneered the electro-dynamic Direct Writing Penmotor as s the various recording systems presented on the following During the past fifteen years, these instruments have helped nds to improve their own products. Brush instruments may e able to help you.

left of this page is a partial list of general applications where Recording Systems have already been used successfully. By g the flyleaf you will find described, the Brush Recording fier generally used for these measurements. On the final pages sted the various single and multichannel oscillographs that the answers" for you.

ps you can make your own selection from the illustrations and ptions of each instrument. However, for descriptive literature engineering assistance on your specific measurement problem, contact your Brush representative—or write us at Brush Elec- s Company, 3405 Perkins Avenue, Cleveland 14, Ohio.

AMPLIFIERS Put MEASUREME



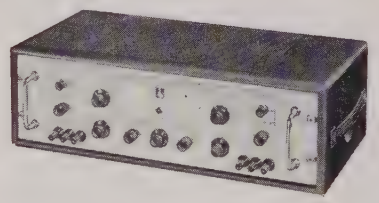
Universal* Amplifier mounted in portable case Model BL-520.

VERY HIGH GAIN CARRI TYPE AMPLIFIER

Maximum Sensitivity: greater tha microvolt per millimeter pen deflecti Range of measurable strain: 0.25 to 4 microinches per inch • May be used 1 to 4 active resistance-sensitive gag with any inductive type transducer can be operated on a 2,000 cycle ca

D. C. MEDIUM GAIN AMPLIFIER SECTION

May be used separately for A.C. and voltage measurements with a max sensitivity of 50 millivolts per millime pen deflection • Input impedan megohm • Precision attenuator in steps.



Dual Channel D. C. Amplifier mounted in portable case Model BL-530.

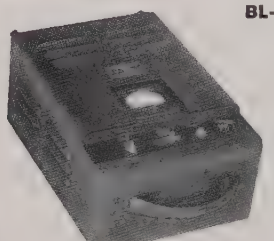
MEDIUM GAIN DUAL CHANNEL D. C. AMPLIFI

Permits simultaneous recording of separate phenomena • Maximum sitivity of 50 millivolts per millime pen deflection • Measurement .050 volts to 200 volts • Input impeda 1 megohm • Both single ended balanced inputs provided.

Direct Coupled Amplifier mounted in portable case Model BL-550.

VERY HIGH GAIN DIRECT COUPLED AMPLI

Chopper stabilized feedback circui ployed eliminates need for matched • Gain of 10,000 • Measurement 100 microvolts to 500 volts • Freq response: from D.C. to 10 kc. • impedance: 1 megohm • Drift: les 25 microvolts per hour after warm Sixteen steps of attenuation to p optimum resolution • Medium Amplifier section will accept either ended or balanced inputs.



PORTABLE A. C. PREAMPLIFIER MODEL BL-954

BL-954 PORTABLE VERY HIGH GAIN A. C. PREAMPL

• Extends range of all Brush amplifie A.C. micro-volt region • Battery op to insure noise level of less than 2 volts RMS • Frequency response: fr to 400 cycles per second • Differen put and output circuit provided • V gain: 200,000 • Internal 50 microvo brating signal.

BL-905 PORTABLE HIGH GAIN A. C. AMPL

Records voltage in frequency range of 100 cycles per second • Maximum s ity: 500 microvolts per millimeter pen tion • Internal calibrating voltage an cating meter provided.

riting On

nportant Features Of nese Brush Amplifiers

nded Frequency Response:

.C. to 100 cycles per second ith Brush Oscillograph. The nplifier alone can provide a fre- ıency response from D.C. to 00 cycles per second.

ırate Calibration:

ternal calibration source per- its accurate D.C. calibration; solute measurement of signal corded.

ision Attenuation:

en step attenuation of input gnal in factors of two and five.

a! Expansion:

en positioning control permits lancing out D.C. or static re- acement of complex signal; ith expansion of the dynamic mponent to be recorded.

Power Consumption:

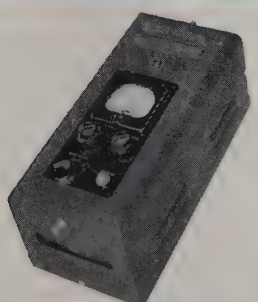
watts (nominal). Less heat to dissipated; less load on power urce.

tronic Voltage Regulation:

sual line voltage and frequency uctuations do not affect accu- cy of recording.

table or Rack Mounted:

ll three models may be mount- l directly in standard 19" racks, may be installed in the acces- ry portable cabinet, BL-380.



PORTABLE A. C. AMPLIFIER
MODEL BL-905

MEASUREME

ELECTRO-DYNAMIC PENMOTOR

Here is the accurate, dependable "hand" records measurements instantly. One or m these Penmotors is incorporated in every Direct-Writing Oscillograph. The Brush E Dynamic Penmotors instantaneously record and dynamic phenomena from D.C. to 100 per second when used with Brush Amp Their high stability and linear phase permit accurate reproduction of both tra phenomena and steady signals. These ments find many uses in industry and re measurements, as well as in electrocardiog geophysical and seismic recording.

EVENT MARKER

Useful on all oscillographs where an ac time base is required or where it is desira synchronize or correlate events, indicate revolutions, etc. Makes a small traverse on or near the margin of the chart paper. able for both right hand and left mountings.

The event markers for the multichannel o graphs are actuated from an internal v source provided. The event markers moun the single and double channel oscillograp actuated from an external D.C. voltage.

TIMING MARKER

The rack mounted oscillographs provide f installation of accessory Timing Marker actuate the left hand Event Markers to p accurate time base marking and a perm indication of the chart speed used for recording.

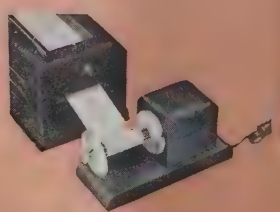
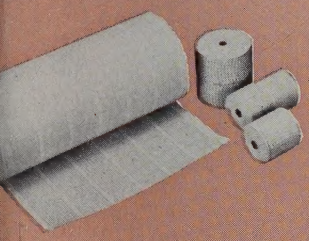


CHART TAKE-UP

The Chart Take-up Drive may be used with the single or double channel Brush oscillo to reel recorded chart paper into a form is readily stored. It is especially useful it is necessary to keep a record or m ments taken over a long period of time. The motor drive system is sufficiently flex permit operation at all oscillograph spee

Writing On BRUSH OSCILLOGRAPHS



HART PAPER

art papers for Brush Oscillographs are radially led in millimeters. Lines of heavier weight e spaced at five millimeter intervals in both e transverse and longitudinal directions.
cording widths are 50 mm. for the single annel paper and 40 mm. for the double and channel papers. Overall paper width is 2⅜" the single channel, 3-7/16" for the double annel, 8" for the four channel and 12" for e six channel.

LOW SPEED CHART DRIVE

ovides three chart speeds of 50, 250 and 50 mm./hour in addition to standard speeds 5, 25, and 125 mm./sec. May be installed any standard single or double channel cillograph by the user, or at the factory. ually supplied with 10 RPM motor but also ailable with 1, 5 and 30 RPM motors, providg corresponding chart speeds.
slow speed chart drive is available as well r the multichannel oscillographs, adding a nge of eight chart speeds in centimeters per ur.

EMOTE CONTROL

vailable for both rack mounted and portable cording systems. Provides complete control of l chart speeds. With BL-264 Four Channel and -266 Six Channel Oscillographs also permits dividual control of recording pens.
e Remote Control Boxes for the four and six annel portable oscillographs also includes e power supply that adds the electric-writing ature.

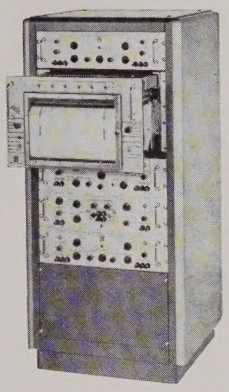
NKING KIT

is kit contains in convenient form the various ols and supplies desirable for insuring conued good performance and maximum usefulss from all Brush Oscillographs and Penmotors.

BRUSH RECORDING SYSTEMS

The Brush Multichannel Oscillographs feature an electrically-controlled chart drive system that permits the instantaneous selection of any recording speed from one centimeter per hour to 250 millimeters per second; a total possible range of 16 accurate chart speeds. This wide range permits the selection of the one chart speed that will provide the desired resolution of signal with maximum economy of chart paper.

All of these oscillographs provide internal reroll of the recorded chart; or the paper may be fed directly from the unit. A transparent door provides easy access to the writing table for notations on the chart itself.

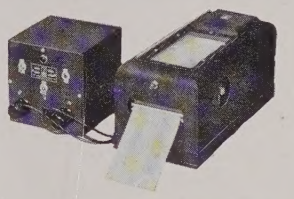


SINGLE AND DUAL CHANNEL OSCILLOGRAPHS

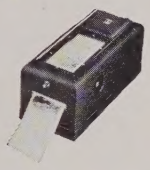
BL-201 Single Channel Oscillograph provides synchronous 5, 25, and 125 mm./sec. The Dual Channel Oscillograph, Model BL-202 permits the simultaneous recording of two variables side by side on one chart.

Combination ink and electric writing models of these oscillographs are also available which include the power supply necessary for the electric writing method.

BL-221 AND BL-222



BL-201 AND BL-202



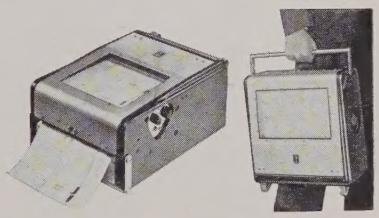
SINGLE & DUAL CHANNEL OSCILLOGRAPHS

PORTABLE OSCILLOGRAPHS

These feature the same multispeed electrically controlled chart drive system with a total choice of speeds available from 10" a day to 10" a second.

Both four and six channel models are available; weighing 40 pounds and 50 pounds respectively.

They are designed for multichannel recording where a need for lightweight and portable instrument is of prime importance.



BL-274 **BL-276**

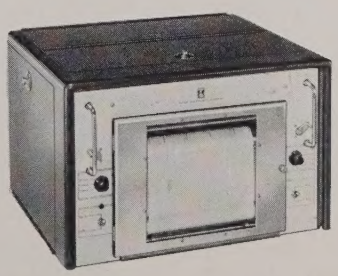
PORTABLE OSCILLOGRAPHS

TYPES OF SYSTEMS

The four and six channel oscillographs Models BL-254, BL-264, BL-256, and BL-266, may be mounted on rack slides in any standard 19" rack or in the bench top console illustrated. Both racks and consoles are available from Brush.

Methods of Writing

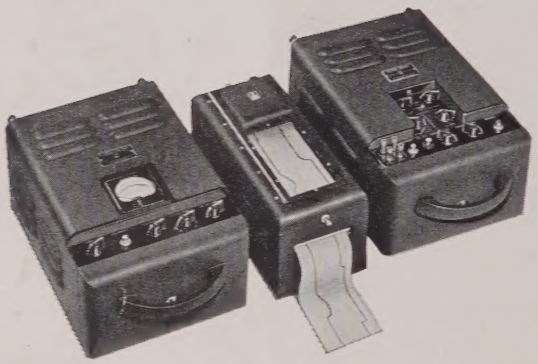
Two methods of direct writing are available with all Brush oscillographs. Ink writing provides dependable permanent records in a choice of colors. Reproductions of the recorded chart paper can be readily made.
Electric writing satisfies requirements for measurements at high altitudes, low temperatures and for unattended operation of the recording system. It produces a clear record of the desired phenomena. Reproductions may be made photographically.
Brush provides both writing systems in the combination ink and electric writing oscillographs. These methods provide a consistently uniform trace, regardless of the chart speed, frequency or type of signal.



BL-254 4 CHANNEL OSCILLOGRAPH IN BENCH TOP CONSOLE

RECORDING SYSTEMS

BRUSH AMPLIFIERS PUT MEASUREMENTS IN WRITING ON BRUSH OSCILLOGRAPHS



WELDING ANALYZER

WELDING ANALYZER BL-213

Provides accurate timing and correlation of three-phase resistance welding variables.

The Model BL-213 Welding Analyzer consists of a modified BL-932 Direct-Coupled Amplifier, Model BL-320 Universal Amplifier, and a special BL-202 Direct-Writing Oscillograph. This instrument was designed to achieve more accurate timing of the D.C. or low frequency weld current and electrode force in the three-phase resistance welding machines—spot, projection and seam.

The Modified BL-932 D.C. Amplifier when used with one channel of the special BL-202 Direct-Writing Oscillograph will record not only the D.C. or low frequency A.C. signals, but will record the 180 cps ripple superimposed on the weld current. Not only can more accurate timing be achieved, but any irregularities in the operation of the electronic tubes controlling the weld current can be observed in the recorded 180 cps ripple signal.

The Brush Model BL-320 is used in conjunction with the other channel of the special BL-202 Direct-Writing Oscillograph to correlate electrode force with the weld current. The immediate recording correlating weld current and electrode force affords a quick and easy method to "set-up" the controls on the resistance welding machine, and also allows for immediate check of the welding machine "set-up" during production operation.

TRANSIENT RECORDER

Electrical transients or any other short-duration phenomena capable of being converted into electrical impulses may be recorded on the Transient Recorder and reproduced automatically on an oscilloscope. The Model BL-502 Transient Recorder is used with an oscilloscope (not furnished) for viewing transient phenomena, after it has first been recorded on the steel tape of the BL-502. Reproduction repeats continuously for visual analysis by a cathode ray oscilloscope. Signals may be photographed in entirety or expanded on the oscilloscope screen to show detail. Any oscilloscope with low-frequency sweep may be used. These results are accomplished by magnetically recording on a rapidly moving steel tape a frequency modulated high-frequency carrier. Reset button clears tape and prepares it for a new record.

This instrument is especially valuable for recording momentary transients such as those produced by vibrations, explosion waves, light flashes, welding cycles and similar occurrences.

MODEL BL-502

or studying transient phenomena of .2 seconds or less.

BRUSH ELECTRONICS COMPANY

DIVISION OF CLEVITE CORPORATION

BRUSH ELECTRONICS

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